OPERATING AND SERVICE MANUAL

-hp- Part No. 00209-90002

MODEL 209A
SINE/SQUARE OSCILLATOR

Serials Prefixed: 818- 00150

Table l-1. Specifications

-RANGES —

Frequency: 4 Hz to 2 MHz in 6 ranges.

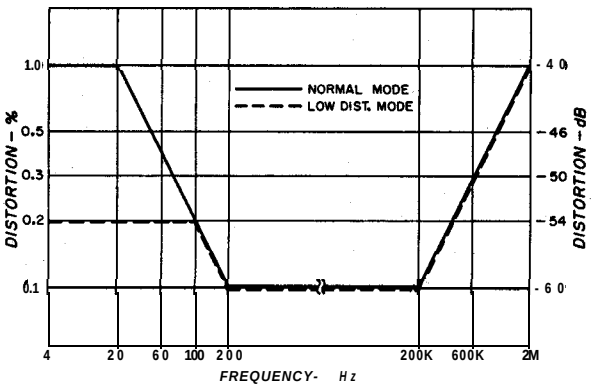
-PERFORMANCE RATINGS —

Dial Accuracy: ±3% of frequency setting.

Flatness: At maximum output into 600 ohm load. **1** kHz reference.

LOW Distortion Mode	±1%	±0.5%	±1%	±5%
Normal Mode	+5% -1%	+/-0.5%	+/-1%	+/-5%
(Hz)	**4**	100	300k	1M 2M

Distortion:



Hum and Noise: less than 0.01% of output.

— OUTPUT CHARACTERISTICS —

SINE WAVE

Output Voltage: 5 V rms (40 mW) into 600 ohms; 10 V open circuit. Output can be floated up to t/-500 V peak between output and chassis ground.

Output Impedance: 600 ohms.

Output Control: 20 dB range continuously adjustable.

Output Balance: greater than 40 dB below 20 kHz.

SQUARE WAVE

Output Voltage: 20 V p-p open circuit symmetrical about 0 V. Output can be floated up to ±500 V peak between output and chassis ground.

Rise and Fall Time: less than 50 ns.

Symmetry: ± 5 %

Output Impedance: 600 to 900 ohms depending upon setting of output control.

-EXTERNAL SYNCHRONIZATION —

Sync Impedance: 10 kilohm.

Sync Output: Sine wave in phase with output; amplitude working into 1 megohm shunted by 100 pF is greater than 1.7 V rms from 4 Hz to 50 kHz, greater than .l V from 50 kHz to 2 MHz.

Sync Input: Oscillator can be synchronized to external signal. For 5 V rms input, sync frequency can be as much as t/-7% away from set frequency (sync range). Sync range is a linear function of sync voltage.

— GENERAL —

Operating Temperature: Instrument will operate within specifications from 0% C to 55% C.

Storage Temperature: -4% C to +75% C

Power: AC-Line 115V or 230V ±10% 48 Hz to **440** Hz, less than 7 W.

Dimensions:
Refer to Figure 2-1, page 2-2.

Accessories Available: HP 11075A Instrument Case.

SECTION I
GENERAL INFORMATION

I-I. INTRODUCTION.

1-2. This section contains general information about the -hp- Model 209A Sine/ Square Oscillator. Throughout this manual the instrument will be referred to as the Model 209A.

1-3. SPECIFICATIONS.

14. Table l-l lists the specifications for the Model 209A.

1-5. DESCRIPTION.

1-6. The Model 209A is a versatile signal source with independent sine wave and square wave outputs at frequencies from 4 Hz to 2 MHz. The square wave amplitude is variable to a maximum of 20 volts peak-to-peak into open circuit. The sine wave amplitude is variable to a maximum of 10 volts rms into open circuit from a constant 600 ohm source. When working into a 600 ohm load, the maximum output level is 5 volts rms.

1-7. Balanced output can be obtained by disconnecting the grounding strap at the rear of the instrument. This isolates the chassis from the cabinet and line ground. The sine wave output will balance to greater than 40 dB, at frequencies below 20 kHz, with the chassis isolated.

1-8. The Model 209A can be synchronized with an external source. With a 5 volt rms sync input, the external source may vary as much as ±7% in frequency and the Model 209A will remain synchronized.

1-9. A sync output of 1.7 volts rms is also available at the same front panel terminal used to accept an external sync source.

I-10. INSTRUMENT/MANUAL IDENTIFICATION.

l-l 1. Hewlett-Packard uses a two-section serial number. The first section (prefix) identities a series of instruments. The last section (suffix) identifies a particular instrument within the series. If a letter is included with the serial number, it identifies the country in which the instrument was manufactured. If the serial prefix of your instrument differs from the one on the title page of this manual, a change sheet will be supplied to make this manual compatable with newer instruments or the backdating information in Appendix C will adapt this manual to earlier instruments. All correspondence with Hewlett-Packard should include the complete serial number.

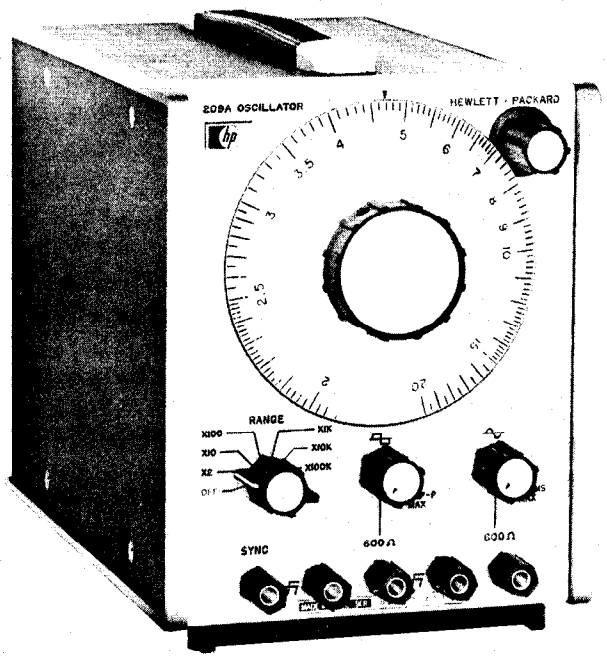
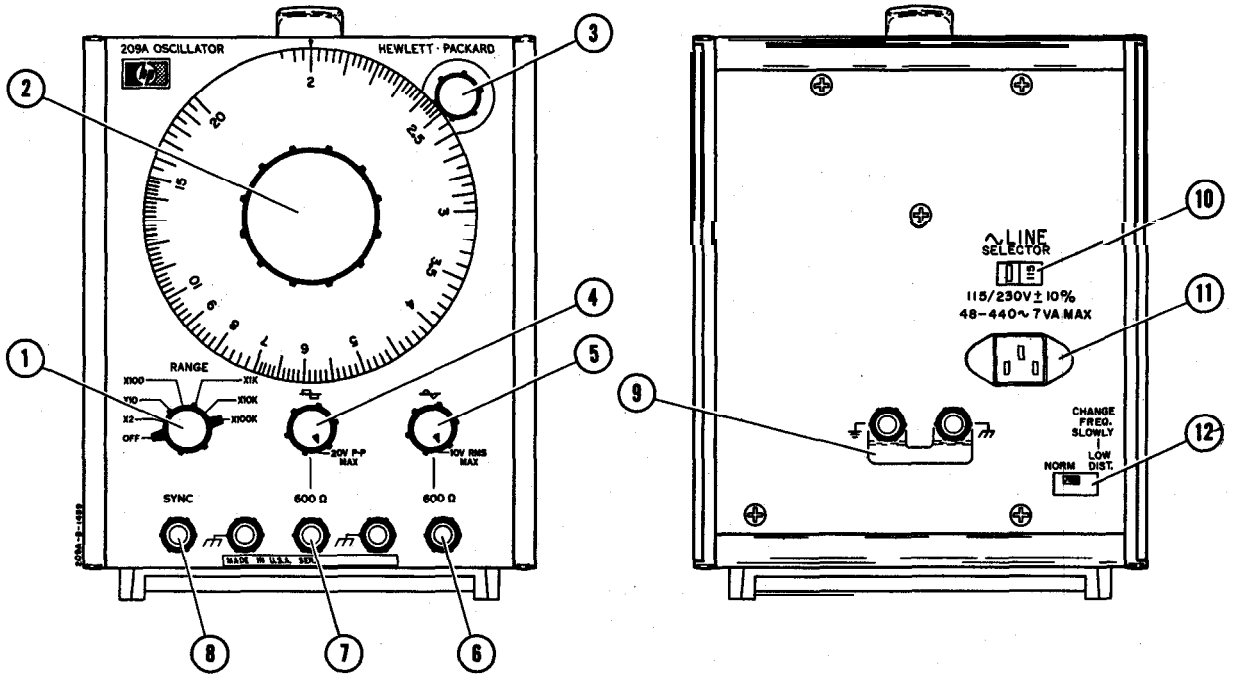


Figure l-1. Model 209A Sine/Square Oscillator



(1) RANGE Switch: Selects frequency range or OFF position.

(2) Frequency Dial: Selects frequency within desired range. Dial setting multiplied by RANGE switch position indicates output frequency.

(3) Frequency Vernier: Provides fine tuning of frequency dial.

(4) Square Wave Amplitude Control: Varies Square Wave output level to 20 volts peak-to-peak, open circuit.

(5) Sine Wave Amplitude Control: Varies Sine Wave output level over a 20 dB range to 10 volts rms, open circuit (5 volts rms into 600 ohms).

(6) Sine Wave Output Terminal: 600 ohm sine wave output at a frequency and amplitude determined by control settings.

(7) Square Wave Output Terminal: 600 ohm square wave output at a frequency and, amplitude determined by control settings,

(8) SYNC Terminal: (1) Input terminal for an external sync signal. (2) Output terminal for 1.7 volt rms sine wave sync signal.

(9) Ground Strap: Connects the floating circuit ground to power ground.

(10) Voltage Selector Switch: Selects line voltage of 115 volts or 230 volts AC.

11 AC Power Receptacle: Mates with power cord supplied with this instrument for line voltage connection.

(12) NORM/LOW DIST. Switch: Selects normal or low distortion below 100 Hz.

Figure 3-1. Description of Controls and Connectors

SECTION III

OPERATING INSTRUCTIONS

3-l. INTRODUCTION.

3-2. This section contains information as an aid to operating the Model 209A. Included are control and connector descriptions (Figure 3-l), and some special operating considerations.

3-3. TURN ON PROCEDURE.

34. To turn on the Model 209A, proceed as follows:

a. Set the two-position voltage selector switch on the rear panel to the value of available line voltage.

b. Connect the AC power cord to line voltage.

c. Switch the RANGE switch from OFF to the desired frequency range.

d. Select the desired frequency and voltage output with the frequency dial and amplitude controls respectively.

3-5. OPERATING CONSIDERATIONS.

3-6. FLOATING OUTPUT.

CAUTION

WHEN THE GROUND STRAP ON THE REAR PANEL IS CONNECTED, INPUT GROUND IS AT EARTH GROUND POTENTIAL.

3-7. When the ground strap on the rear of the Model 209A is disconnected, the chassis is isolated from power ground. The outputs may then be connected to any point with a dc potential of not more than +/-500 volts. If a dc voltage up to +/-500 volts is connected between the ground connectors on the rear panels, the oscillator output is dc offset by that amount.

3-8. BALANCE.

3-9. With the chassis isolated from the cabinet, the sine wave output will be balanced to greater than 40 dB at frequencies below 20 kHz. If the square wave output is being used simultaneously with the black terminal connected to ground, the sine wave output will no longer be balanced.

3-10. SYNCHRONIZATION.

3-l 1. The Model 209A is equipped with a SYNC terminal that provides a sync output signal or accepts a synchronizing input signal from an external source. The sync output signal is a 1.7 volt rms sine wave in phase with the oscillator output. The external sync signal can be any periodic waveform of sufficient amplitude to maintain sync. For an external sync signal with an amplitude of 5 volts rms, the oscillator will remain synchronized at frequencies of ± 7 % of the set frequency.

3-12. The Model 209A can be synchronized to any significant harmonic of an external signal. However, if a harmonic or non-sinusoidal waveform is used to synchronize the Model 209A, some portion of the external sync signal will be on the output. This small signal will appear as distortion. The amount of this apparent distortion will be directly proportional to the amplitude of the sync signal. For a non-sinusoidal sync input of 2 volts peak-to-peak, the distortion will be down about -45 dB for frequencies which are normally down -60 dB.

3-13. LOW DISTORTION.

3-14. At frequencies below 100 Hz, distortion can be reduced by switching the NORM/LOW DIST switch on the rear panel to LOW DIST. In the LOW DIST mode .the Model 209A will have a longer settling time when changing frequencies. To avoid this, set the desired frequency before switching to LOW DIST.

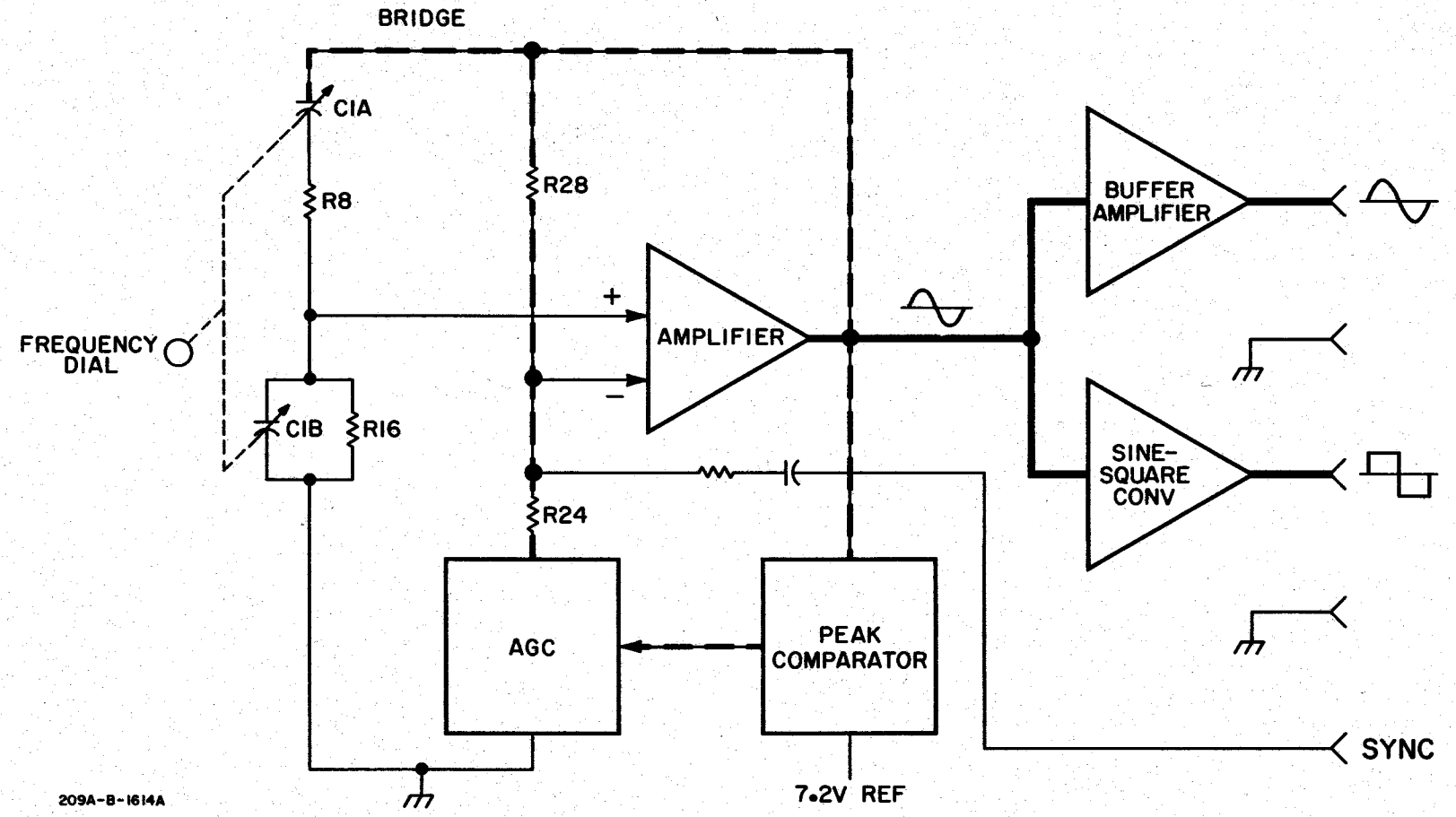


Figure 4-1. Model 209A Block Diagram

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains a description of the basic principles of circuit operation for the Model 209A. The information is presented as a discussion of each block indicated on the Block Diagram, Figure 4-1, and detailed circuit descriptions which refer to Figure 7-1 and 7-2.

4-3. The Model 209A is basically a Wien bridge oscillator. The output from the oscillator circuit is applied to a buffer amplifier and to a sine wave to square wave converter. These two circuits provide independent sine wave and square wave outputs, respectively.

4-4. BLOCK DIAGRAM DESCRIPTION.

4-5. BRIDGE AND AMPLIFIER.

4-6. An overall loop gain of at least unity is a requirement for any amplifier to oscillate. The Model 209A satisfies this requirement with a combination of positive and negative feedback through the bridge.

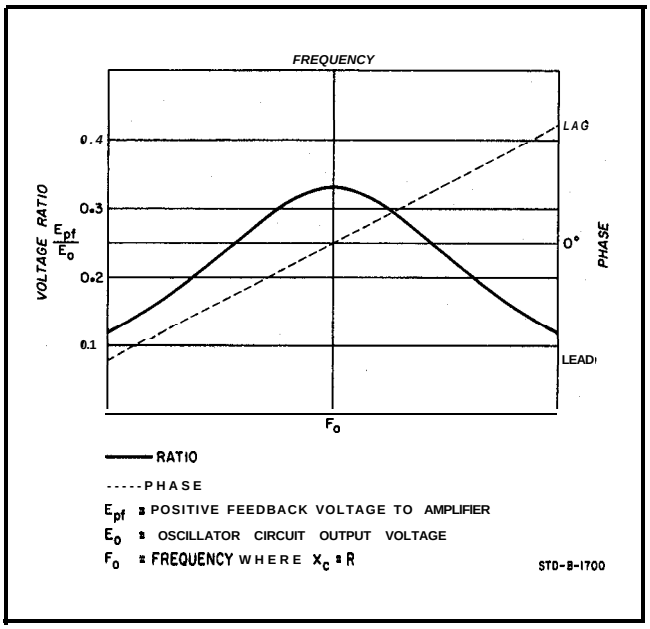


Figure 4-2. RC Frequency Network Characteristics

4-7. The oscillator bridge is divided into two networks, the frequency selective network and the negative feedback network. Positive feedback is furnished through the frequency determining network of C1A R8, C1B and R16. At the frequency that the phase of the positive feedback is 0^0, X_c = R and the maximum ratio of output voltage is supplied to the amplifier (see Figure 4-2). The characteristics of the Wien bridge are such that the output voltage to the + input of the amplifier at F_o is one third the amplitude of the positive feedback voltage. Therefore, to maintain unity gain and oscillation, the negative feedback network (R28, R24 and AGC) was designed with a divider ratio of two to one, to give the amplifier a gain of three.

4-8. The amplifier itself is a solid-state, high gain amplifier with the output in phase with the input so that feedback will produce oscillations.

4-9. PEAK COMPARATOR AND AGC.

4-10. The voltage output from the Wien bridge to the input of the amplifier is not always one third of the positive feedback voltage at all operating frequencies, nor is the amplifier gain constant for all operating frequencies. One technique used for maintaining unity gain in the oscillator circuit at all operating frequencies is to have a dynamic resistance, variable with changes in gain, in the negative feedback network. In the Model 209A this is accomplished with the combination of the peak comparator and AGC circuits.

4-11. The peak comparator compares the negative peak of the oscillator amplifier output to a 7.2 volt reference. If the output varies above or below the reference voltage, a difference voltage will be supplied to the AGC circuit. The "dynamic resistance" of the AGC circuit is a field-effect transistor with the gate controlled by the difference signal from the peak comparator. The oscillator amplifier output is held to 7.2 volts peak amplitude.

4-12. When the oscillator is first turned on, the AGC gives the amplifier a gain of much greater than three. Noise in the amplifier is amplified greatly, and the frequency selective network in the Wien bridge selects the noise at the tuned frequency. The selected noise becomes positive feedback to the amplifier, and the amplifier starts oscillating at the tuned frequency. As the output amplitude approaches 7.2 volts peak, the

AGC reduces the gain of the amplifier to three; and stable oscillation is achieved.

4-13. BUFFER AMPLIFIER.

4-14. The 5 volt rms sine wave output from the oscillator circuit is coupled to the buffer amplifier. The amplifier has a high open loop gain that is controlled by the negative feedback to provide a gain of 2. This enables the circuit to have very low distortion characteristics. The buffer amplifier uses a complementary symmetry transistor pair to furnish a 10 volt rms output.

4-15. SINE-SQUARE CONVERTER.

4-16. The 5 volt rms sine wave output from the oscillator circuit is also applied to the sine-square converter. The sine wave is coupled to a tunnel diode which produces a small square wave output with fast rise and fall times. This small square wave signal is then shaped and amplified. It appears at the output as a 20 volt peak-to-peak square wave.

4-17. DETAILED CIRCUIT DESCRIPTION.

4-18. For the following paragraphs, refer to the Oscillator Schematic Diagram, Figure 7-1.

4-19. Transistors AlQl through AlQ7 make up the basic oscillator amplifier. AlQl is an N-channel FET. AlCRl sets up proper dc bias for AlQ2. Diodes AlCR6, AlCR7, AlCR8 set up proper bias for AlQ4. Capacitor AlC9 is chosen to provide a stable roll off at high frequencies. AlQ7 is a current source for AlQ3 and AlQ4. AlCR4 and AlCRS provide proper biasing for complementary output transistors AlQ5 and AlQ6.

4-20. The positive feedback arm of the Wien bridge consists of tuning capacitors AlClA and AlClB, and range switching resistors Al Rl through Al R17.

4-21. The negative feedback arm of the Wien bridge depends upon the ratio of the impedance of AlR28 to the total impedance of AlR23, AlR24, AlR25, and AlQ8. AlR25 reduces the effect of the FET AlQ8 to increase stability. AlQ8 provides AGC for this amplifier by varying impedance to obtain the proper negative feedback.

4-22. The conduction of FET AlQ8 is controlled by the peak detector circuit using Al Q9. Al Q9 conducts during the most negative portion of each negative half cycle, developing a negative charge in AlC15 and its parallel capacitors. As the amplifier output amplitude increases, AlQ9 conducts more and AlC15 becomes more negatively charged. This makes the FET input voltage more negative, increasing its impedance and increasing the negative feedback to reduce the output. amplitude of the amplifier.

4-23. Transistors Al Q13 through Al Q18 comprise a buffer amplifier with a gain of two. AlQ13 and Al Q14 form a differential amplifier. Diodes AlCR18 and AlCR19 furnish proper biasing for complementary output transistors Al Q17 and AlQ18. When the output attenuator AlR79 is fully clockwise, the output amplitude is greater than 10 volts rms. When the attenuator is fully counter-clockwise, the output is attenuated by greater than 20 dB.

4-24. The Sine-Square Converter circuit includes AlQl0 through AlQ12. This converter circuit operates as a saturating amplifier. Tunnel diode AlCR12 squares the sine wave input, and the Symmetry Adjust AlR45 determine the level where conduction starts. This provides for adjustment of the symmetry of the square wave. Zener diode AlCRlS sets the voltage level of the negative portion of the square wave. Al Q12 furnishes the positive portion of the square wave output, and AlQll furnishes the negative output.

4-25. POWER SUPPLY.

4-26. The following paragraphs refer to the Power Supply Schematic, Figure 7-2.

4-27. This power supply is a series regulated power supply furnishing +21 volts and -21 volts. Zener diode A2CR6 serves as a reference for the positive power supply, which in turn serves as the reference for the negative supply. The positive supply is described here, and the negative supply operates similarly.

4-28. Transistor A2Ql regulates the output voltage and is controlled by A2Q3. A2Q2 is a current source for A2Q3. Zener diode A2CR5 furnishes bias for A2Q2, while A2R2 injects negative ripple feedback. A2CR6 sets the emitter voltage of A2Q3, setting up a reference for the supply output. current limits the output to prevent damage to the supply.